The Survivability Analysis Framework (SAF)

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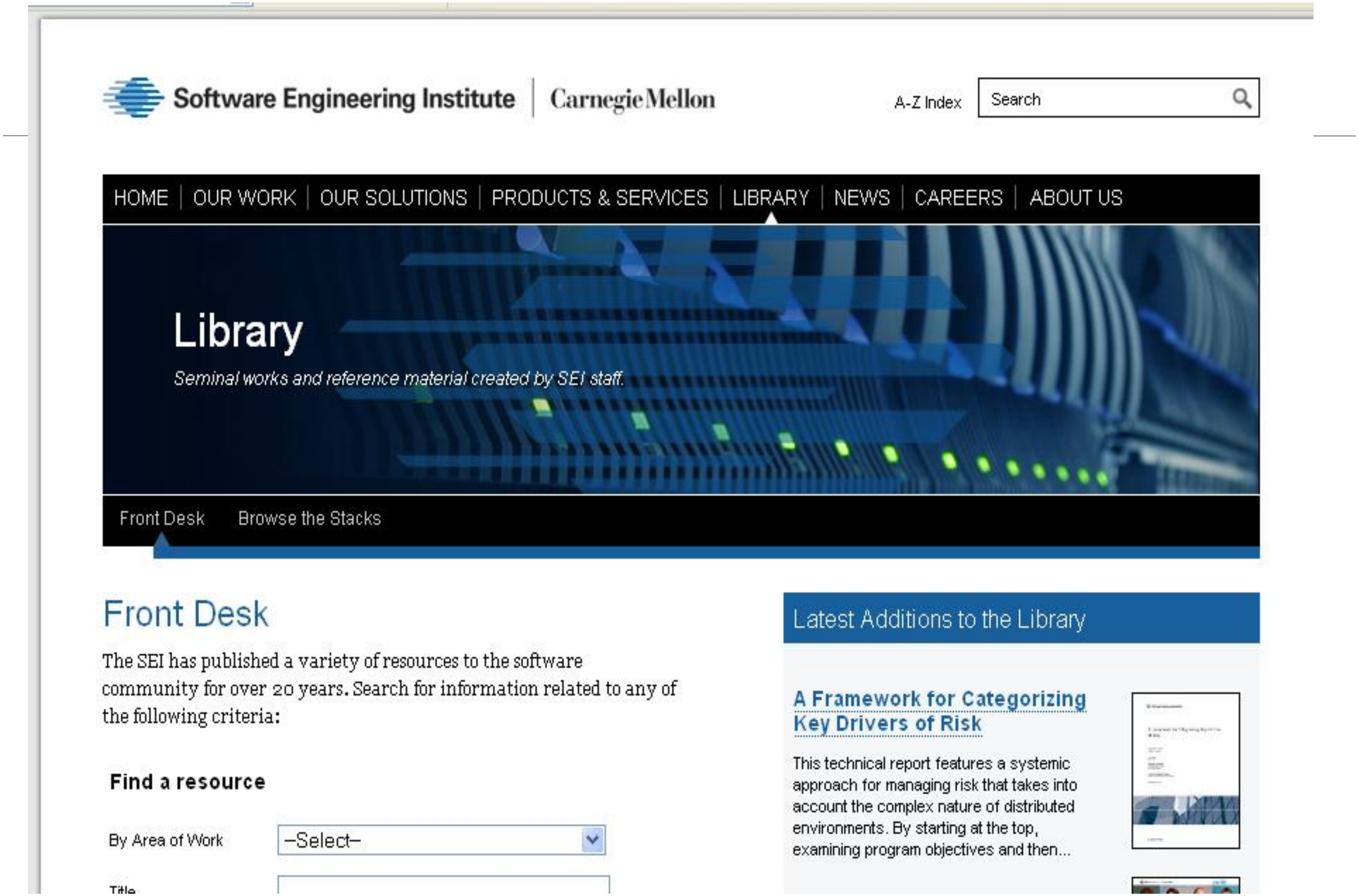
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About Carol Woody

Sr. Member of the SEI Technical Staff

Leads a team in CERT addressing critical gaps in assurance and survivability

25 years of experience in software management, acquisition, development, and implementation in large complex organizations

Polling Question 1

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Why a Framework

The framework was developed to address the following research questions:

How can mission survivability be maintained as interoperability of systems increases?

Research sponsored by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD [AT&L])

How can operational impacts (such as information security) be tied to technology changes in operational mission execution?

U.S. Air Force’s Electronic systems Center (ESC) Cryptologic Systems Group (CPSG)

Piloted in 8 complex operational environments

Framework Description

Purpose of the Framework

Establish an approach for assembling the broad range of operational information (technology, people, and processes) to analyze it for survivability

- Failure responses must be planned – unexpected usage (malicious or accidental) that drives operational execution outside of expected behaviors
- Survivability must be considered within the context of other quality attributes (performance, usability, etc.)
- Complexity and change are unavoidable so inconsistencies (mismatches) must be assumed as we compose technology, people, and processes
- Operational compositions span organizational and technology boundaries

Change is Always Occurring

Survivability must accommodate the usual and the unexpected

Usual problems

- Power and communication outages
- Snow storms
- Staff illness & death

Expected changes

- New technology insertion
- Technology refreshes
- Location moves
- Operational security

Catastrophe is a matter of scale

Polling Question 2

What is your organization’s most critical operational concern?

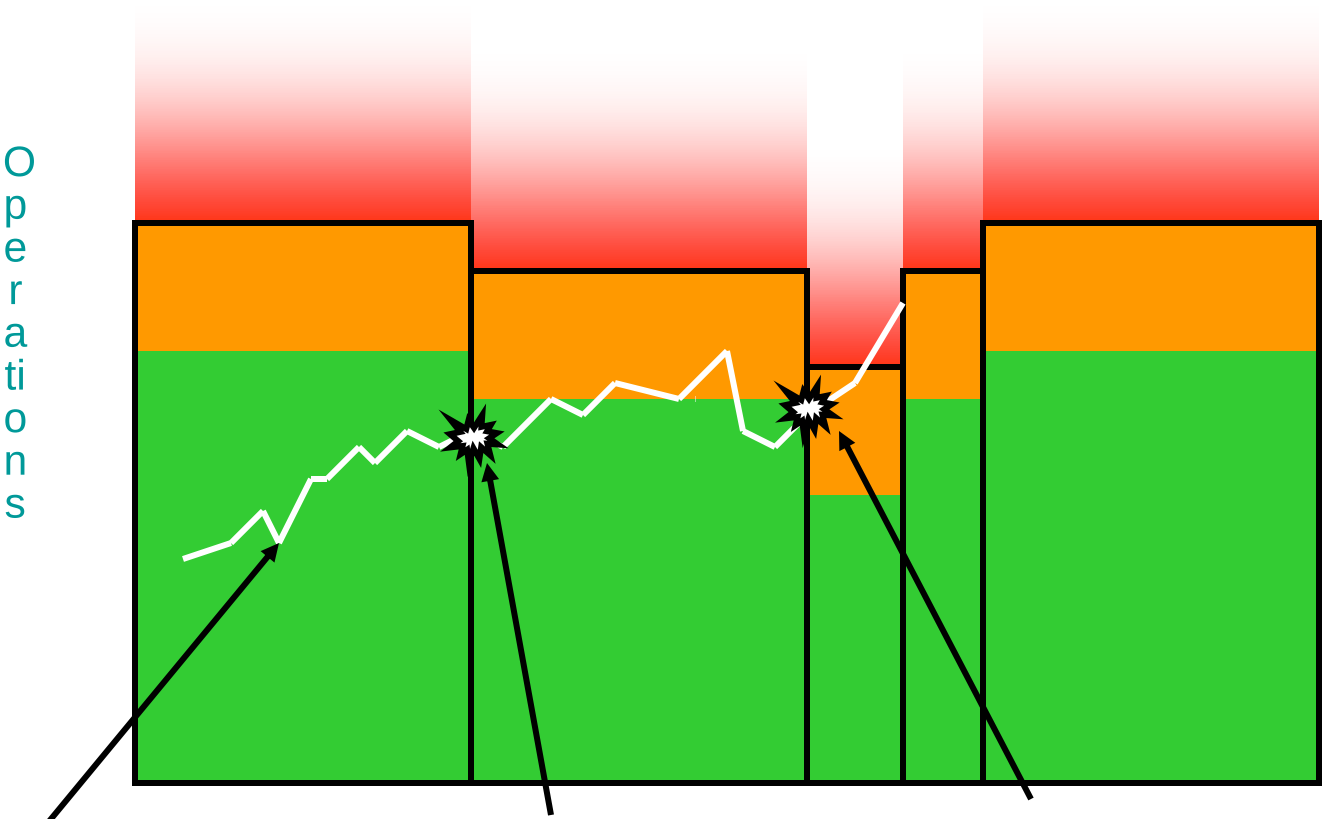
a) Continuity of operations

b) Natural disaster response

c) Contractual compliance

d) Vulnerability management

Failure Model of Catastrophe



EVENT

A failure or change

Increase in work load or usage

Reduction in capacity

Activity

An event edges system state closer to Orange zone.

A second event followed by increased usage pushes state towards Red.

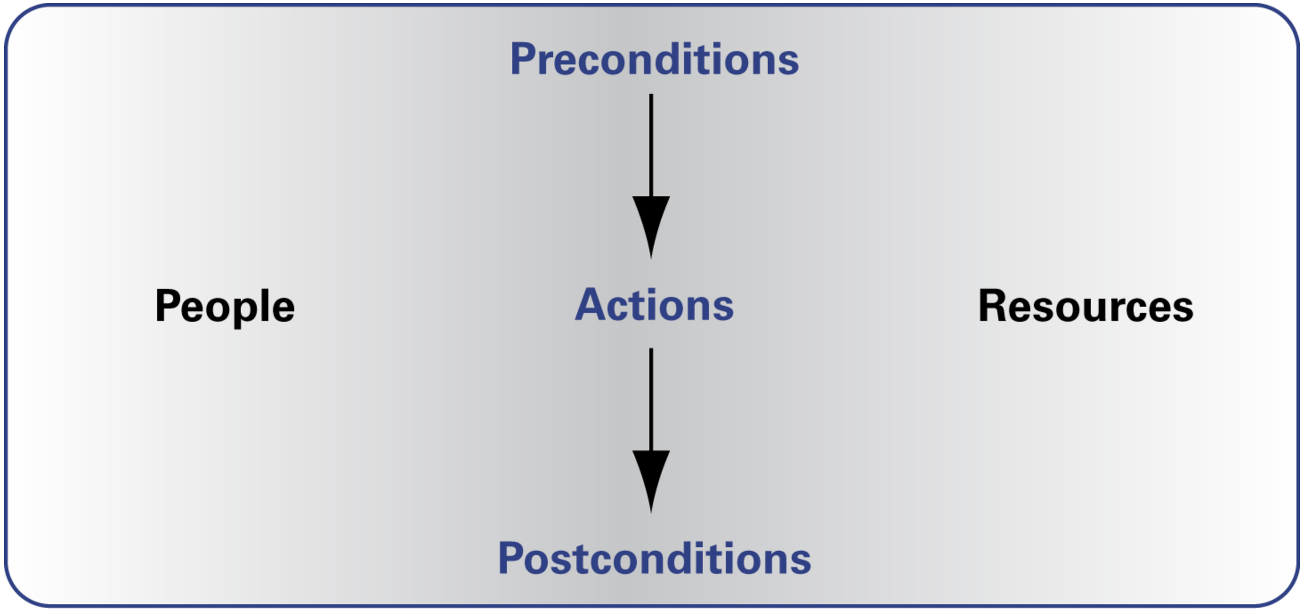
Survivability Analysis Framework (SAF) - 1

Framework for operational survivability analysis

Process:

- Select a critical business process for detail analysis
  - specific example of people applying technology to perform an operational mission
- Identify operational success criteria
- Describe critical steps in depth
  - Sequenced activities
  - Participants
  - Resources
- Identify and analyze ways critical steps may not function as intended and opportunities for mitigation

Survivable Analysis Framework (SAF) - 2



Stresses → **Acceptable Outcomes**

Analysis

- *Potential failure conditions*
- *Likelihood of error conditions*
- *Impact of occurrences*
- *Recovery strategies*

People and Resources

People can include

- direct performers of operational actions
- data entry, inquiry, verification, audit, synthesis among multiple information sources, administration for technology components, authentication and authorization authorities

Resources can include

- hardware—servers, data storage devices, PCs, PDAs, routers, telephone switches, satellite relays, physical access controls, and similar devices
- software—operating systems for each hardware platform, configuration management, databases, firewalls, network protocols, packet switches, authentication packages, Web applications, local and remote procedures
- policies and practices—certification and accreditation, third-party access management, outsourcing
- contracts, governance controls, and the like

Polling Question 3

Do you analyze the operational survivability of your critical business processes (missions)?

a) Yes

b) No

Example 1: Doctor Orders Blood Test

Simple example to show the structure of information used in SAF

Focus on failure analysis

Mission Thread Examples

Example 1: Scenario Steps

A. Patient brought to emergency room with chest pains.

B. Dr. Emergency reviews available records

C. Dr. Emergency develops a treatment plan.

D. Dr. Emergency orders series of blood tests.

E. Phlebotomist from laboratory arrives to collect first specimen which is sent to the lab.

F. Lab receives specimen, performs centrifuge and delivers serum to appropriate testing stations.

G. The Lab system notifies the ordering system that the specimen has been received for testing.

Example 1: Operational Context

Doctor is using a handheld device to review patient records, to record information during the exam, to order tests, and to receive test results.

The Lab is a separately run business that has contracted to provide services to all of the local hospitals.

For privacy purposes, the Lab does not have patient-specific information. The Lab bills the hospital, and the hospital bills the patient.

Example 1: Time-line of Actions - People

Describe how each person/organization is involved in each step and who has controlling authority (C)

Action People	A: Emergency Room Encounter	B: Doctor reviews patient records	C: Doctor develops treatment plan	D: Doctor orders blood tests	E: Phlebotomist arrives and take specimen
Patient	C				X
Doctor	X	C	C	C	
Lab Phlebotomist					C
Lab Technician					

Example 1: Time-line of Actions - Resources

Describe the resources involved in an action

Action **Resources**	A: Emergency Room Encounter	B: Doctor reviews patient records	C: Doctor develops treatment plan	D: Doctor orders blood test
Handheld device		X	X	X
Hospital Communication Hub		X	X	X
Hospital Admissions	X			
Hospital medical records		X	X	
Hospital Lab communications				X
Lab Systems				X

Example 1: Describing a Critical Step

Step D	**Doctor orders blood tests**
Precondition	Treatment plan defined Required lab tests identified Handheld connectivity to Lab Dr. E. authorization to order tests for this patient
Action	Enter order on handheld Order accepted, verified, and accepted by Lab
Post-Condition	Test confirmed and scheduled

Example 1: Failure Outcomes for Step D

Missing (or delayed) results:

- some or all tests are not done

Wrong results:

- some unrequested tests were performed
- results do not reflect the actual sample

Disclosure:

- results are disclosed to unauthorized person
- test results are not associated with the correct patient
- test results are not associated with the correct doctor

Example 1: Causes of Failure

Failure: Missing test results

- Paperwork requiring tests to be run was lost or misplaced
- Blood samples were lost, contaminated, or misplaced
- Some tests were not run by the technician
- Wrong tests were run by the technician
- Some or all test results were not associated with the correct patient by the lab
- Some or all test results were not associated with the right doctor by the lab
- Testing machine did not produce results
- Testing machine was not working and could not produce results

Example 2: Joint Military Operation

Complex example to show how the SAF structuring of information supports analysis

Focus on the impact of technology change on operational survivability

Example 2: Military Joint Forces Mission Thread

An army unit on patrol spots a missile launcher preparing to fire. The unit calls their commander and provides a description of the launcher and its location. Even though the launcher is in the Army’s area of responsibility, in this scenario the Army does not have an appropriate weapon to bring to bear (for example, the artillery could be in use on other targets). However, the Air Force has a suitable platform and is tasked as Executive Agent to further prosecute or strike of the target. The Army remains the authority for the strike even though the Air Force will perform the engagement.

Example 2: Scenario Steps

1. Army unit sees “something” (e.g. Missile launcher preparing to fire.)
2. Unit calls their command post via satellite connection and provides a description of the launcher and its location.
3. UAV is moved into position to evaluate the potential target.
4. Army Command notifies Joint Services of a critical target requesting approval and support
5. Joint Services approves the target for critical support
6. Joint Services review weapon(s) and delivery platform options based on timing, collateral damage, desired effect, etc.
7. Air Force plane selected to attack target
8. Order transmitted to pilot (usually verbally)
9. Pilot executes attack coordinated by JTAC (ground resource embedded in Army unit)
10. Multiple assessments lead to unified battle damage assessment (BDA)

Example 2: Operational Context

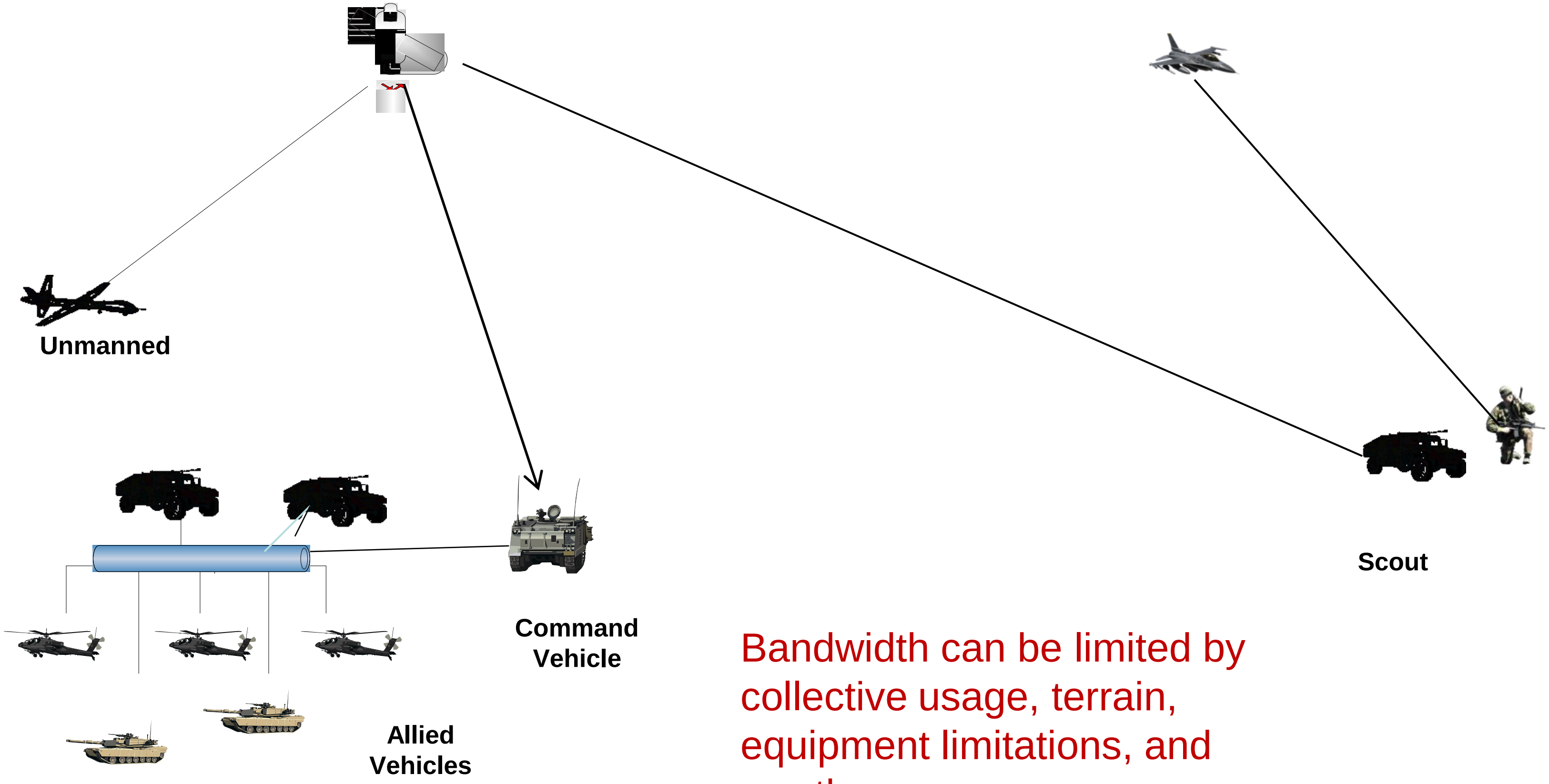
Mixture of communication mechanisms with high degradation potential

Wide spectrum of failure potentials (battle operations)

Wider spectrum of stakeholders (with potentially conflicting needs)

Multiple systems and their interactions (each participant is independent operator participating in system of systems)

Example 2: Mission Interactions



Bandwidth can be limited by collective usage, terrain, equipment limitations, and weather.

Example 2: Describing a Critical Step

Step 9	**Target Attack**
Precondition	Communication between JTAC and aircraft established Communication between JTAC and Army Target, friendlies, etc are “marked” appropriately
Action	Army approval: The supported army ground unit provides approval to the JTAC to release the weapons. Synchronization of target identification JTAC provides target corrections to aircrews as needed JTAC clears or aborts aircraft to attack
Post-Condition	Target is attacked

Example 2: Mission Critical Resource

Evaluate changes to a mission critical resource in Step 9

- JTAC and Aircraft establish secure communications

Potential resource context changes over time

- Currently voice, line of site (LOS)
- Enhanced to text and voice, LOS with satellite backup
- Expanded to satellite image sharing from UAV to JTAC and JTAC to aircraft

Example 2: Critical Resource Impact Evaluation

Failure impact potential:

- High: mission abort, mission errors with fratricide, wrong target
- Medium: mission delays; insufficient attack power; loss of IA for mission (exposure)
- Low: future mission potential

Selected failures for JTAC to aircraft communication (changes)

- Failure of communication connection – high impact (reduced with satellite backup)
- Partial transmission (retry required) – medium impact (increases with more channels – using more bandwidth)
- Encryption failure for communication – medium impact (unchanged)
- Incompatible communication software – medium to high impact (increases)

Example 2: Failure Analysis

For each failure option:

- Outcome for resource if failure realized (disclosure, modification, loss/destruction, unavailable)
- Impact on mission of compromised resource
- Impact rating (high, medium, low)
- Mitigations
- Response strategy (accept, monitor, mitigate)

Changes to system and software requirements resulting from decisions to mitigate

Polling Question 4

Do you consider the potential of operational failure when evaluating technology changes?

a) Yes

b) No

Multi-View Decision Making (MVDM)

Provides an approach that addresses the breadth and depth of activities, decisions, and products that must come together to successfully address complex software development

Evaluate and compare the mission, the integrated operational execution, and acquisition

- Mission-Oriented Success Analysis and Improvement Criteria (MOSAIC)
- Survivability Analysis Framework (SAF)
- System of Systems Interoperable Acquisition

Using SAF with Other Analysis Techniques

Security Assurance Case

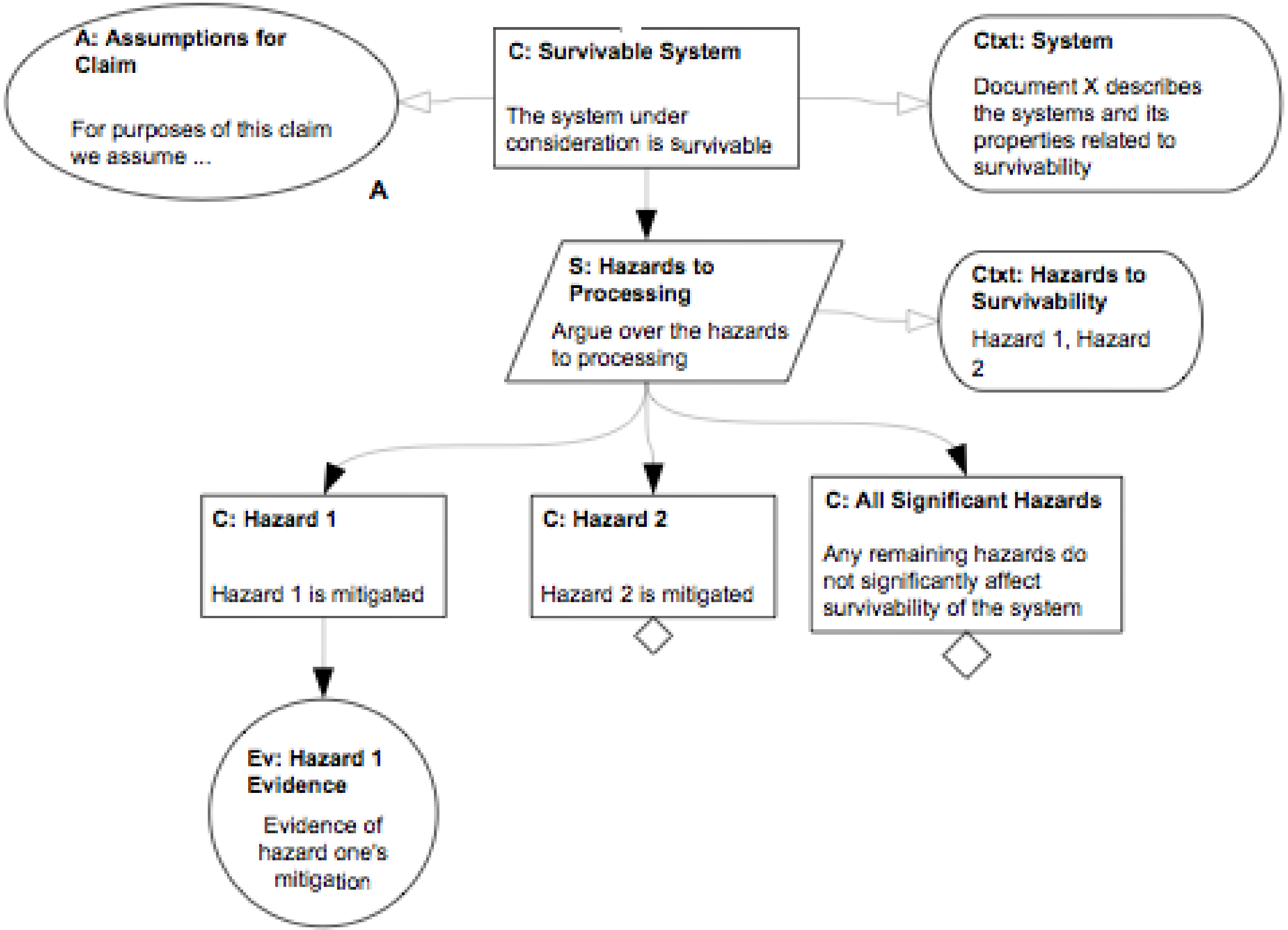
Structured view (claims, arguments, and evidence) that describes how potential security failures are addressed

- Connects mitigations with the threats they are addressing
- Identifies assurance gaps (missing evidence of mitigations)

Example Claim: Supplier follows suitable security coding practices

- Sub-claim: Supplier bans and enforces the ban on use of dangerous application programming interfaces
- Sub-claim: Static analysis tools with appropriate vulnerability coverage are applied at appropriate times throughout development
  - Evidence: Percentage of current code subject to static analysis
  - Evidence: Listing of applicable coding weaknesses
  - Evidence: Percentage of applicable coding weaknesses covered

Assurance Case Structure


A: Assumptions for Claim
For purposes of this claim we assume ...
A
C: Survivable System
The system under consideration is survivable
Ctxt: System
Document X describes the systems and its properties related to survivability
S: Hazards to Processing
Argue over the hazards to processing
Ctxt: Hazards to Survivability
Hazard 1, Hazard 2
C: Hazard 1
Hazard 1 is mitigated
C: Hazard 2
Hazard 2 is mitigated
C: All Significant Hazards
Any remaining hazards do not significantly affect survivability of the system
Ev: Hazard 1 Evidence
Evidence of hazard one's mitigation

Summary

Use SAF to Plan for Survivability

Plan for normal operation and failure response

- Develop range of mission threads that are critical for normal operations
- Identify critical mission activities, participants, and resources
- Evaluate the range of unexpected behaviors that could contribute to mission failure
- Mitigate potential failure

Plan for operational mission impact of technology changes

- Identify critical mission resources affected by proposed changes
- Evaluate the operational impact of failures in the current and changed operational context
- Identify change requirements based on mitigations for survivability

Questions?

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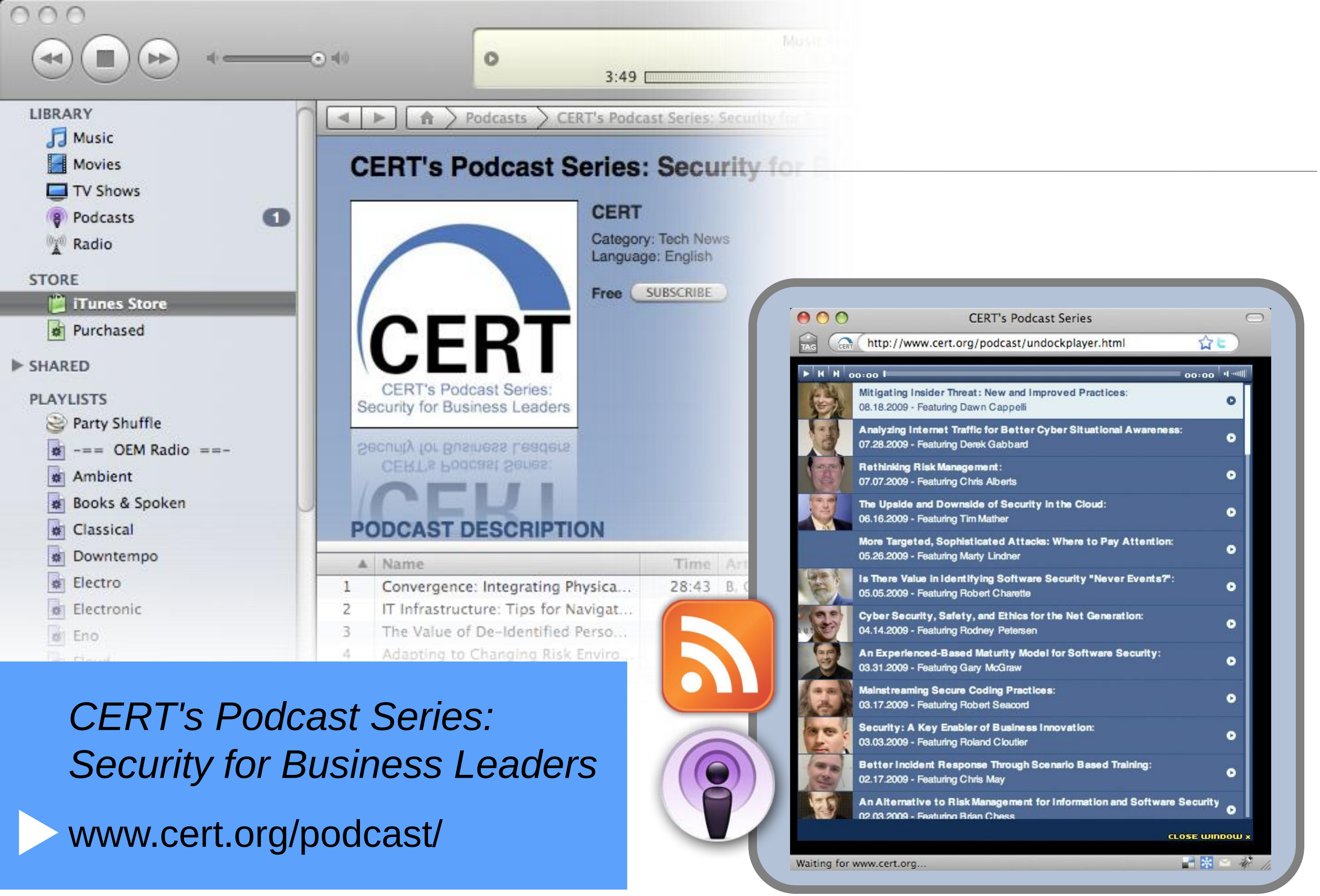

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